Why Has It Been So Wet Lately?

The large-scale atmospheric patterns behind the record/near record wet April

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What is with the weather lately? Last year at this time, we had come off the warmest March on record and we were in the process of setting the stage for a significant drought that would ultimately intensify during the summer and become the worst drought since 1988. This year, of course we cannot buy any spring warmth, and the abundance of rainfall over the past week has caused record breaking flooding and has also resulted in this April being the wettest on record in Chicago.

With only a few days left in the month of April, it appears that the monthly average temperature will end up somewhere around 46.5 (46.1) degrees in Chicago (Rockford), which is a couple of degrees below the average. After a relatively mild winter, this will mark the third month in a row of temperatures below average. Although these cool temperatures have not been record breaking, they have been noteworthy. If we consider the average temperature during March and April, it appears that this two month period could rank the in the top 32 (12) coldest on record at Chicago (Rockford). Additionally, the number of days with high temperatures at or below 45 degrees in both March and April was 33 (32) days in Chicago (Rockford). The normal is around 21 days in Rockford and 25 in Chicago. This ties, with a few other years, as the 18th (4th) most in history at Chicago (Rockford), and also represents the most days during the two months since 1993 (1983). For comparison, last year there were only about 17 such days, when we experienced the warmest two month period on record at both Chicago and Rockford.

Precipitation has also been exceptionally above average, especially within the last week, when many locations received upwards of 5 inches of rain from April 17th into April 18th, causing record flooding on many area rivers. Thus far, Chicago has received a total of 8.65 inches of rain for the month of April. This has already set the new record for the wettest April in Chicago. Meanwhile, this April currently ranks as the third wettest on record in Rockford, with a total of 7.94 inches. This heavy rain of late now gives the area about an 8.5 inch surplus of rainfall for the calendar year, which has largely made up for the 8 to 12 inch deficit that was common across the region during the 2012 calendar year.

The big question is what has changed to lead to such drastic differences in temperatures and precipitation lately? To answer this question we much consider the behavior of the large scale weather pattern across North America and the adjacent oceans. There are certain large scale weather flow patterns that can be very favorable for cool and wet conditions across the central United States, while others can favor dry and warm conditions. Also, sometimes these preferred large scale patterns can lock in place for an extended period of time, producing extended periods (weeks or months) of similar weather conditions. Then, after some time, the large scale weather pattern may change rapidly. These rapid changes in the weather pattern can lead to more "active" weather periods across portions of the country.

Consider the left hand side of figure 1 below, which displays the atmospheric pressure anomalies in the mid and upper portions of the atmosphere across North America and the adjacent oceans. The warm colors are positive anomalies and the cool colors are negative anomalies. The things to point out here are the very high positive pressure anomalies over the high latitudes of North America and Greenland and the lower pressures across the eastern half of the United States and into the central Atlantic. These pressure anomalies were associated with the negative phase of the North Atlantic Oscillation (-NAO) and the Arctic Oscillation (-AO). These patterns were the strongest during March. Overall, these oscillations are simply a north to south dipole pattern of atmospheric pressure anomalies of opposite sign between the high latitudes and the middle latitudes of the Northern Hemisphere. The NAO is similar to the AO, except that it is a measure of these pressure anomaly patterns over the North Atlantic. The positive phase of these oscillations would show high pressure over the eastern United States and the central Atlantic with low pressure across the high latitudes. Strong atmospheric pressure patterns such as these are important because they have a large influence on the strength and geographical placement of the cold season upper level jet stream over North America.

In the case of this past February and March, we experienced a transition towards cooler than normal conditions across much of the region as this pattern set up (right side of figure 1). The strong negative pressure anomalies across the eastern United States pushed the jet stream farther south across the country, allowing more persistent cold Canadian air to spill in across the eastern half of the country. This pattern also helped drive some more substantial winter storms across the central portion of the country. Prior to February and March, the NAO was primarily in at least a weakly positive phase and this helped produce a fairly warm and snowless start to the winter season.

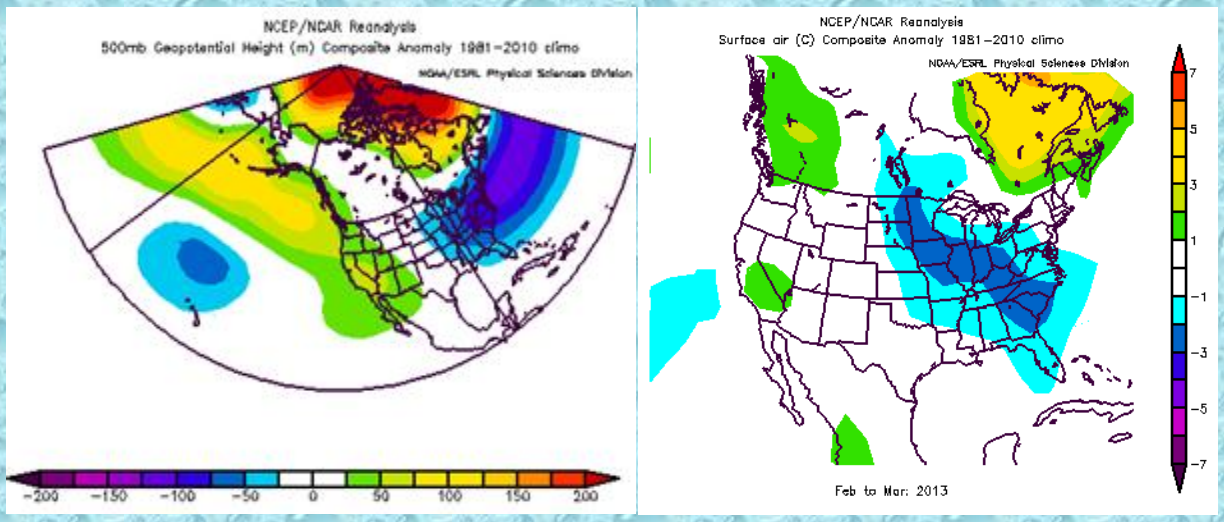

Figure 1 Upper level atmospheric pressure anomalies across North America (left), and surface temperature anomalies (right), during February and March 2013.

More recently, Figure 2 below shows that the large scale pattern changed significantly. The top portion of the figure shows the behavior of the NAO over the past few months. Notice how the NAO was generally in its negative phase in late February through the first part of April, then all of sudden spiked well into the positive phase around the middle of April. Similarly, the Pacific North American (PNA) began to rapidly shift from a neutral state (near 0) into its negative phase. The PNA pattern is another preferred pressure pattern

across North America and the Pacific Ocean that can significantly affect the strength and position of the upper level jet stream. The PNA also has a positive and a negative phase similar to the NAO and AO patterns. However, unlike the NAO and AO, the PNA references pressure anomaly patterns of the same sign between the northern Pacific, just south of the Aleutians, and the southeastern coast of North America, and also between the central Pacific, near Hawaii and the western United States.

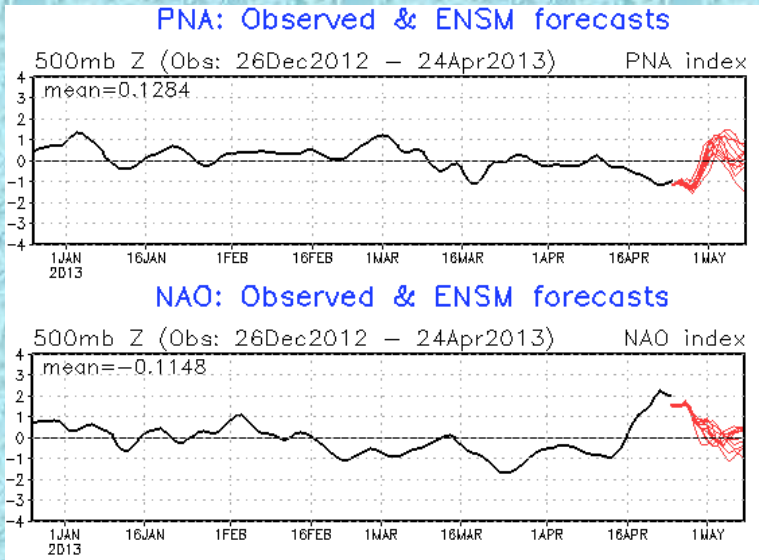

Figure 2 Time series of the North Atlantic Oscillation (NAO) (top), and the Pacific North American (PNA) (bottom).

Overall, the rapid switch to a -PNA and +NAO suggested that the large scale weather pattern across North America and The Pacific was rapidly changing into a pattern supportive of very active weather across the central United States. Figure 3 below shows the atmospheric pressure anomalies during the period of April 14th through April 21st. The negative PNA pattern is evident from the strong positive pressure across the north Pacific and across the southeastern United States, as well as negative pressure across the central Pacific and the western United States. Meanwhile, the +NAO pattern is evident from the negative pressures across the high latitudes near Greenland and the positive pressures across the eastern United States and central Atlantic. These pressure patterns support the presence of a much stronger upper level southwesterly jet stream right across the mid-Mississippi valley and Great Lakes region and an influx of Gulf Moisture in the lower levels of the Atmosphere.

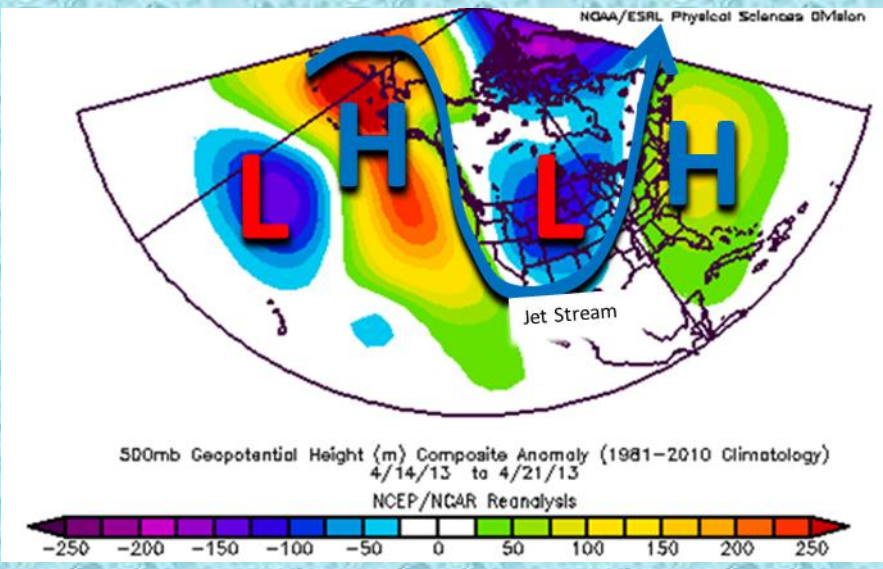

Figure 3 Upper level atmospheric pressure anomalies during the period April 14th through April 21st 2013. Warm colors are positive anomalies and the cool colors are negative. Also shown are the high and low pressure centers and the inferred upper level jet stream pattern.

Ultimately this significant pattern shift was responsible for the development of a strong storm system across the plains during the middle of April. This storm system was responsible for transporting an unseasonably moist Gulf of Mexico air-mass across the lower Great Lakes region. The end result was that showers and thunderstorms had a nearly endless supply of moisture and they were very efficient heavy rainfall producers. Strong storm systems can and do typically develop during large and rapid large scale pattern shifts such as this. It is the atmosphere's way to seek out a balanced state, when it is knocked out of balance. The big challenge that is faced in meteorology is trying to predict with several days lead time when these big large scale pattern changes will occur and how they will affect the weather locally.

Here at NWS Chicago, starting over the weekend prior to the event, we did key on the consistent signal appearing on computer guidance for a strong system over the center of the country drawing up highly anomalous moisture content from the Gulf of Mexico ahead of it, potentially setting the stage for very heavy rainfall and flooding. This was highlighted in the Hazardous Weather Outlook on Sunday April 14th and Monday April 15th, with a Hydrologic Outlook issued Monday and early Tuesday and a Flood Watch issued for all of northern Illinois and northwest Indiana on Tuesday afternoon, April 16th.

Additional Links:

The Record Flooding of April 17-18: Crests, Rainfall, Photos, and Setup

Wettest April on Record for Chicago!

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